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# VIDEO AMPLIFIER CIRCUITS FOR MULTI-OUTPUT DISTRIBUTION OF VIDEO SIGNALS

## Field of the Invention

The present invention relates generally to video signal communications, and more particularly to distribution of video signals.

## Background of the Invention

Increasingly, existing homes and homes under construction are being "networked" wherein communications cables (video, data, and/or telecommunications cables) are being extended to many rooms and, in some cases, to multiple locations within each room. The benefits of "home networking" may include the ability to network multiple computers, printers and peripherals throughout a home and to access the Internet through a single high-speed connection; to watch an internally modulated video signal such as a video cassette recorder (VCR), digital video disk (DVD), or satellite television receiver from any room in the home; to use a digital phone system, such as an ISDN line, throughout the home; to add security video cameras in the home and view them on any television; and to add future equipment that may allow a homeowner to use the same hand-held remote control in any room.

Home networking typically requires the use of a central distribution panel which serves as a gateway or interface to various communications services. Within these central distribution panels, cable distribution modules are typically

utilized to receive a cable from a service provider and distribute the service provided among various communications cables that are routed throughout the home. For example, a video cable distribution module may be configured to receive a cable television signal from a cable television service provider and distribute the signal to multiple cables routed within a home. Cable distribution modules may be amplified or non-amplified to divide signals to multiple communications cables, depending upon the number of communications cables involved.

An exemplary central distribution panel **10** with a plurality of video/cable distribution modules **11a, 11b, 11c** is illustrated in **Figure 1**. With the exception of electric power, communications services entering a home are typically routed into the central distribution panel **10**. From the central distribution panel **10**, distribution cables and, consequently, the services they provide, are routed to wall taps in various locations throughout a home. Conventionally, the service provided at a particular wall tap is determined by the cable's connection in the central distribution panel **10**. For example, if a wall tap is connected to a computer networking hub, a computer networking service is provided at the wall tap. By moving the connection in the central distribution panel **10** from the computer networking hub to a telecommunications module, the service at the wall tap may be changed to telephone service.

One challenge with providing such a flexible distribution approach to video signals is the potential signal degradation caused by splitting video signals such as cable television (CATV) signals. For a typical CATV system, splitting a source signal out to more than four output signals may result in unacceptable signal degradation when using a splitter without amplification. Home distribution systems, such as those described above, are known to provide dual stage video amplifier circuits allowing up to 16 way splitting while still providing an acceptable signal quality. An even greater number of outputs from a signal input can be provided with available single stage high power video amplifiers,

such as an ACA0861C available from Anadigics of Warren, NJ. However, such circuitry is typically cost prohibitive for the home distribution environment.

## Summary of the Invention

Embodiments of the present invention provide video amplifier circuits. The video amplifier circuits include a first stage amplifier having a high signal gain and a low noise figure and having an input coupled to a video input signal and an output. A second stage amplifier having a high output power and a low distortion has an input electrically coupled to the output of the first stage amplifier and an output. A splitter circuit has an input coupled to the output of the second stage amplifier and a plurality of outputs. In various embodiments, the output power of the second stage amplifier is greater than 23 decibels millivolts (dBmV) into 75 ohms and the distortion of the second stage amplifier is Composite Triple Beat (CTB) 56 decibels below carrier (dBc) and/or Composite Second Order (CSO) 58 dBc. The signal gain of the first stage amplifier may be greater than 15 decibels (dB) and the noise figure of the first stage amplifier may be less than 3.5 dB and further may be less than 1.5 dB. The first stage amplifier may be an RF2320 amplifier and the second stage amplifier may be an RF2317 amplifier and the splitter circuit may include more than 16 outputs and even 32 or more outputs.

In other embodiments of the present invention, a first matching circuit couples the video input to the input of the first stage amplifier. A second matching circuit couples the output of the first stage amplifier to the input of the second stage amplifier. A first biasing circuit is electrically coupled to the output of the first stage amplifier and a second biasing circuit is electrically coupled to the output of the second stage amplifier. A direct current (DC) blocking circuit couples the output of the second stage amplifier to the input of the splitter circuit.

In further embodiments of the present invention, the video input signal is a video input/output signal for bi-directional communications and the video

amplifier circuit further includes a diplexer circuit having an input electrically coupled to the video input/output signal and a high frequency output electrically coupled to the input of the first stage amplifier and a low frequency connector. A return channel amplifier circuit is electrically coupled between the low frequency connector of the diplexer and the input of the splitter circuit. A combiner circuit couples the return channel amplifier and the second stage amplifier to the input of the splitter circuit. The bi-directional communications may be digital over cable systems interface specification (DOCSIS) protocol communications. The video amplifier circuit may also include a first return channel matching circuit coupling the return channel amplifier to the combiner circuit and a second return channel matching circuit coupling the return channel amplifier to the diplexer circuit.

In other embodiments of the present invention, cable distribution modules are provided for routing a DOCSIS compatible connection with a cable network to a plurality of connection points. The module includes a cable input configured to be connected to the cable network. A diplexer circuit is electrically coupled to the cable input and splits a signal on the cable input into a forward and a return channel. A return channel amplifier circuit is electrically coupled between the plurality of connection points and the diplexer circuit on the return channel. A two stage amplifier circuit is electrically coupled between the diplexer circuit and the plurality of connection points on the forward channel. The two stage amplifier circuit includes a first stage amplifier having a high signal gain and a low noise figure and a second stage amplifier having a high output power and a low distortion. A combiner circuit couples the return channel amplifier circuit and the two stage amplifier circuit to the plurality of connection points. A splitter circuit couples the combiner circuit to the plurality of connection points.

In further embodiments of the present invention, the cable distribution module also includes one or more internal video signal inputs. An internal signal amplifier circuit is electrically coupled to the internal video signal inputs. A

second combiner circuit is coupled between the first combiner circuit and the splitter circuit and is electrically coupled between the internal signal amplifier circuit and the splitter circuit. The cable input may receive a cable television (CATV) signal in a first frequency band. Each of the internal video signal inputs may have an associated frequency band different from the first frequency band so that a receiver connected to one of the plurality of connection points may select between the CATV signal and the internal video signals as a received signal by tuning to an associated frequency band for one of the signals. A third combiner circuit may be provided to couple the plurality of internal video signal inputs to the internal signal amplifier circuit. The splitter circuit may include at least 32 connection points.

In other embodiments of the present invention, video distribution modules are provided for routing a video connection to a plurality of connection points. The modules include a video input configured to receive a video signal from either an antenna or a cable network. A two stage amplifier circuit is electrically coupled between the video input and the plurality of connection points. The two stage amplifier circuit includes a first stage amplifier having a high signal gain and a low noise figure and a second stage amplifier having a high output power and a low distortion. A splitter circuit is coupled between the two stage amplifier circuit and the plurality of connection points. In addition, one or more internal video signal inputs may be provided with an internal signal amplifier circuit electrically coupled to the internal video signal inputs. A combiner circuit may then be coupled between the two stage amplifier circuit and the splitter circuit and electrically coupled between the internal signal amplifier circuit and the splitter circuit.

## Brief Description of the Drawings

**Figure 1** is a front elevational view of a conventional cable distribution panel illustrating various video/cable distribution modules therein;

**Figure 2** is a block diagram of a video amplifier circuit according to embodiments of the present invention;

**Figures 3A** is a circuit diagram of a video amplifier circuit according to embodiments of the present invention; and

**Figure 3B** is a circuit diagram including additional components which may be included in a video/cable distribution module according to embodiments of the present invention in cooperation with the video amplifier circuit of **Figure 3A**.

## Detailed Description of the Invention

The present invention now will be described more fully hereinafter with reference to the accompanying drawings, in which preferred embodiments of the invention are shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. Like numbers refer to like elements throughout. In the drawings, layers, objects and regions may be exaggerated for clarity.

The present invention will now be described with reference to the embodiments illustrated in the figures. Referring first to **Figure 2**, embodiments of video amplifier circuits according to the present invention will be further described. As shown in **Figure 2**, a video input signal (VideoIn) is provided to an input of a first stage amplifier **110**. The first stage amplifier **110** is selected to have a high signal gain and a low noise figure. Preferably, the signal gain of the first stage amplifier is greater than 15 decibels (dB) and the noise figure of the first stage amplifier **110** may be less than 3.5 dB and may further be less than 1.5 dB. The output of the first stage amplifier **110** is provided to an input of the second stage amplifier **115**. The second stage amplifier **115** is a high output power, low distortion amplifier. Preferably, the output power of the second stage amplifier **115** is greater than 23 dBmV and the distortion of the second

stage amplifier **115** is greater than about CSO 58 dBc and CTB 56 dBc. An output of the second stage amplifier **115** is coupled to an input of the splitter circuit **120**. The splitter circuit **120** has a plurality of outputs.

By combining a high gain, low noise first stage amplifier with a high power, low distortion second stage amplifier, the present invention may provide for improved conditioning of an input video signal and, thereby, may support a greater number of distribution points than known two stage amplifiers without such a combination. In particular, amplifiers according to embodiments of the present invention may support a splitter circuit **120** which includes more than 16 outputs and, preferably, at least 32 outputs. Such capabilities may be supported in accordance with the present invention without incurring the greater expense typically associated with available high end, single stage high power amplifier circuits which would otherwise be needed to support this many outputs.

Also shown in dotted lines for the embodiments of **Figure 2** is optional return channel support circuitry. It is known that video signals, such as cable television (CATV or cable) signals are often used for bi-directional communications. To support such communications carried by a common cable, a return channel amplifier circuit **125** is shown in the embodiments of **Figure 2**. A splitter (or diplexer) circuit **130** is provided to separate the forward and return channel circuitry at the video signal input point (VideoIn) and a combiner circuit **135** is shown recombining the signals at the input to the splitter circuit **120**. Typically, a different frequency band is assigned to the forward and reverse channels. for example, a low frequency band may be provided for one direction and a higher frequency band for the opposite direction. Furthermore, a gap may be provided between the bands providing an offset between the two channel directions. For example, the return channel may be allocated to the band below 42 Megahertz (Mhz) while the forward channel may be allocated to a frequency band above 54 Mhz. An example of such bi-directional communications is

provided by the digital over cable systems interface specification (DOCSIS) protocol.

Embodiments of the present invention will now be further described with reference to the circuit diagram illustration of **Figures 3A** and **3B**. **Figure 3A** illustrates a bi-directional amplifier circuit according to embodiments of the present invention for processing a video signal connected to a splitter circuit **300** having a plurality of outputs. **Figure 3B** illustrates additional internal video signal input circuitry connected to the splitter circuit **300** which may be utilized in a video/cable distribution module according to various embodiments of the present invention.

It is to be understood that, while specific components along with specific values for such components are illustrated in **Figures 3A** and **3B** to aid in understanding the present invention, the invention is not limited to these specific combinations of components or component values. For example, a plurality of resistors of a first value connected in parallel could be replaced by a lesser number (including one) of resistors of different value(s). In addition, the illustrated components may be provided as discrete devices or integrated onto a custom integrated circuit device wherein the connection between illustrated components may be understood to be between "terminals" or "connections" or "inputs" or "outputs" of respective devices regardless of the specific fabrication technology used to provide the electrical coupling between respective devices. As used herein the terms "coupled" or "connected" refer to a connection which may include intervening devices or components while the terms "directly connected" or "directly coupled" refer to a connection without any intervening devices or components.

Referring first to **Figure 3A**, a video input, such as an antenna or CATV (cable) input **205**, receives the video input signal for amplification and splitting. A matching circuit **210** couples the video input **205** to a diplexer **215**. As shown in **Figure 3A**, the matching circuit **210** includes an inductor **L101** (shown as 6.8

in nH) and a resistor **R110** (shown as 12 (resistor value references are ohms herein)).

The diplexer **215** (shown as a **DX100**) has an input electrically coupled to the video input signal **205** and a high frequency output **225** and a low frequency connector **230**. The high frequency output **225** couples to a high signal gain, low noise, first stage amplifier **240** (**A100**) (shown as an **RF2320** available from RF Micro Devices, Inc. of Greensboro, North Carolina) through a first matching circuit **235**. The matching circuit **235** includes an inductor **L105** (shown as 8.2nH) and may include an optional resistor **R117** (shown as 0 ohms).

The first stage amplifier **240** is electrically coupled to a high output power, low distortion second stage amplifier **250** (**A101**) (shown as an **RF2317** available from RF Micro Devices, Inc.) through a second matching circuit **245**. The second matching circuit **245** includes an inductor **L106** (shown as 6.8nF) and a capacitor **C112** (shown as 330 pF) for DC blocking. The matching circuit **245** may further include a capacitor **C107** (shown as 0.5 pF) and capacitor **C111** (shown as 1.5 pF) which may be provided for noise control/filtering.

A first biasing circuit **255** is coupled to the output of the first stage amplifier **240** and a second biasing circuit **260** is electrically coupled to the output of the second stage amplifier **250**. The fist biasing circuit **255** includes an inductor **L102** (shown as 3.3 μH), a bypass capacitor **C105** (shown as 1μF) and a bypass capacitor **C106** (shown as 680 pF). The second biasing circuit **260** includes an inductor **L103** (shown as 3.3 μH), a bypass capacitor **C113** (shown as 1μF), a bypass capacitor **C114** (shown as 680 pF) and resistors **R112-R116** (shown as 23.2). In addition, a direct current (DC) blocking circuit is provided at the output of the second stage amplifier **250** by the capacitor **C115** (shown as 330 pF).

The circuit illustrated in **Figure 3A** includes circuitry for supporting a video input/output signal at the video input **205** for bi-directional communications by inclusion of a return channel circuit. The return channel circuit includes a

return channel amplifier circuit **275** coupled between the low frequency connector **230** of the diplexer **215** and a combiner circuit **265** (**S100**). The combiner circuit **265** electrically couples both the return channel amplifier circuit **275** and the second stage amplifier **250** to the splitter circuit **300** shown in **Figure 3B**.

In addition to the return channel amplifier circuit **275**, the return channel further includes a first return channel matching circuit **280** coupling the return channel amplifier circuit **275** to the combiner circuit **265** and a second return channel matching circuit **290** that couples the return channel amplifier circuit **275** to the low frequency connector **230** of the diplexer **215**. Finally, a 3 dB pad **285** is shown in the return channel circuit of **Figure 3A**. The first return channel matching circuit **280** includes a capacitor **C103** (shown as 0.1 μF) and a resistor **R106** (shown as 20). The second return channel matching circuit **290** includes an inductor **L100** (shown as 39 nH), a resistor **R100** (shown as 20) and a capacitor **C100** (shown as 0.1 μF). The 3 dB pad **285** includes resistors **R107**, **R109** (shown as 442) and a resistor **R108** (shown as 26.7). A power circuit **295** is also illustrated in **Figure 3A** for providing electrical power to the amplifier circuitry described herein.

Further aspects of various embodiments of the present invention will now be described with reference to the circuit diagram of **Figure 3B**. A plurality of internal video signal inputs **305** are shown in **Figure 3**. While three inputs are shown in **Figure 3**, it is to be understood that additional internal video signal inputs could be provided by connecting splitters, such as six-way or eight-way splitters, to each of the three inputs **J200, J202, J206** shown for the plurality of internal video inputs **305**. For example, the input **J206** could be connected to a six-way splitter allowing up to six security camera signal inputs to be connected into the circuitry. In turn, the connector input **J200** could be connected, for example, to a variety of DVD, VCR or other video signal sources within a

residence using the video amplifier circuits of the present invention in a cable or video distribution module.

A combiner circuit **310** couples the plurality of internal video signal inputs **305** to an internal signal amplifier circuit which is shown in **Figure 3B** as a two stage amplifier circuit including a first amplifier **320** and a second amplifier **325**. The first amplifier **320** has a biasing circuit **330** coupled to its output and the second amplifier **325** has a biasing circuit **335** connected to its output. Similarly, the first amplifier **320** has a tilt circuit **340** connected to its output and the second amplifier **325** has a tilt circuit **345** connected to its output which tilt circuits may be used to compensate for frequency roll off in the combiners.

The first biasing circuit **330** includes resistors **R200-R204** (shown as 464), an inductor **L200** (shown as 560nH), a capacitor **C204** (shown as 1μF) and a capacitor **C205** (shown as 680pF). The second biasing circuit **335** includes resistors **R205-R208** (shown as 511), an inductor **L201** (shown as 560nH), a capacitor **C207** (shown as 1μF) and a capacitor **C208** (shown as 680pF).

The first tilt circuit **340** includes an inductor **L202** (shown as 39nH), a resistor **R209** (shown as 100) and a DC blocking capacitor **C213** (shown as 0.1μF). The second tilt circuit **345** includes an inductor **L203** (39nH), a resistor **R210** (shown as 100) and a capacitor **C214** (shown as 0.1μF).

The combiner circuit **350** combines the amplified video/cable input signal from the combiner **265** and the amplified internal video signal output from the second stage amplifier **325** and electrically couples the combined signal to the splitter circuit **300**. The splitter circuit **300**, as illustrated in **Figure 3B**, shows a four-way splitter configuration. However, a 32-way splitter configuration may be provided by connecting each output **J201**, **J203, J204, J205** to an eight-way splitter to provide a total of 32 outputs from the splitter circuit **300**. Other combinations may also be provided in a similar manner.

It will be understood that the block diagram and circuit diagram

illustrations of **Figures 1-3B** and combinations of blocks in the block and circuit diagrams may be implemented using discrete and integrated electronic circuits. It will also be appreciated that blocks of the block diagram and circuit illustration of **Figures 1-3B**, and combinations of blocks in the block and circuit diagrams may be implemented using components other than those illustrated in **Figures 1-3B**, and that, in general, various blocks of the block and circuit diagrams and combinations of blocks in the block and circuit diagrams, may be implemented in special purpose hardware such as discrete analog and/or digital circuitry, combinations of integrated circuits or one or more application specific integrated circuits (ASICs).

Accordingly, blocks of the circuit and block diagrams of **Figures 1-3B** support electronic circuits and other means for performing the specified functions, as well as combinations of operations for performing the specified functions. It will be understood that the circuits and other means supported by each block and combinations of blocks can be implemented by special purpose hardware, software or firmware operating on special or general purpose data processors, or combinations thereof.

The foregoing is illustrative of the present invention and is not to be construed as limiting thereof. Although a few exemplary embodiments of this invention have been described, those skilled in the art will readily appreciate that many modifications are possible in the exemplary embodiments without materially departing from the novel teachings and advantages of this invention. Accordingly, all such modifications are intended to be included within the scope of this invention as defined in the claims. In the claims, means-plus-function clauses are intended to cover the structures described herein as performing the recited function and not only structural equivalents but also equivalent structures. Therefore, it is to be understood that the foregoing is illustrative of the present invention and is not to be construed as limited to the specific embodiments disclosed, and that modifications to the disclosed embodiments, as well as other embodiments, are

intended to be included within the scope of the appended claims. The invention is defined by the following claims, with equivalents of the claims to be included therein.